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March 20, 1967

Dr.

Dear Dr.

Attached is a proposal for a Research Contract, Physiological Mechanisms Underlying the Electrodermal Response and their Behavioral Significance, which will allow continuation and extension of work performed under our original Contract

The designated principal investigator would again be Dr. It is requested that this contract, if approved, become effective June 1, 1967.

Sincerely yours,

Approved for Release
Date 27 Feb 1972

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Proposal

Physiological Mechanisms

Underlying the Electrodermal Response

and their Behavioral Significance

From

March 20, 1967

Period of Work

This proposal would cover one year of effort.

Facilities

In addition to equipment originally available, there is now an additional 4-channel D.C. polygraph purchased under the current contract, and a 2-channel magnetic tape recorder with FM components for recording of biological signals.

Amount of Support

An estimate of costs is attached. Contractual financial arrangements are proposed as exist under the current contract with the exception that indirect costs be calculated at the negotiated rate of 30 percent.

Reports

It is proposed that scheduling of progress reports be continued on the same basis as described in Contract.

Principal Investigator

Cost Estimate

Principal Investigator (part-time)

Research Assistant (full-time)

Electronics Technician (half-time)

Subjects

Stenographic Services

Reproduction Services

Expendable Supplies (Paper, chemicals, electronic components, etc.)

Solid state special purpose computer components

Impedance Bridge

Magnetic Recording Tape

Travel (2 coordination trips @

Sub-Total

Overhead at 30% (Negotiated Rate)

Total

PHYSIOLOGICAL MECHANISMS UNDERLYING THE
ELECTRODERMAL RESPONSE AND THEIR BEHAVIORAL SIGNIFICANCE

I. INTRODUCTION

Reference is made to the description of background and statement of proposed work described under current contract terminated in June 1966. Further reference is made to an interim Progress Report dated February 15, 1967, which describes progress to January 31, 1967. The original contract was aimed at a systematic investigation of the basic physiological mechanisms responsible for electrodermal reflex events in the hopes that the understanding of their nature would aid behavioral interpretation and afford a rational basis for effective data treatment. Attention was to be given to the relative involvement (or lack of involvement) of vasomotor, sudomotor and epidermal activity in this reflex, to the special characteristics of the response which might be associated with each component, to the principles governing the addition of component activities, and to the specific classes of stimuli which evoke activity in the respective components. Efforts were to be made to identify the nature of the biological adaptation signified by the activity of each component in efforts to recognize their psychological significance.

The initial phases of this work (as described in the February 15, 1967, interim progress report) consisted of experiments as follows:

- (a) Comparison of microelectrode recordings from sweat pores and areas between sweat pores. These have since been extended to comparison of surface recordings with those at the deepest level of the stratum corneum.
- (b) Comparison of recordings from the corneum in different states of hydration.
- (c) Recordings from cat foot-pad under varying patterns of stimulation of the sympathetic nerve supply.
- (d) Recordings of potential responses from the nail plate which is allegedly free of sweat glands.
- (e) Study of the effect of surface electrolytes on the specific components of the skin potential response.
- (f) Production of local electrodermal responses by mechanical stimulation (calibrated stretch) and alteration of this response by chemical agents, ischemia, temperature change, and combination with activity of central origin.

(g) Examination of the effects on skin potential response of vascular changes produced by engorgement (venous cuff), arterial occlusion, or exsanguination by a directed massage.

(h) Comparison of electrodermal behavior as measured by constant voltage vs constant current systems.

The results of these experiments together with those already reported in the literature were utilized in the development of a new hypothesis describing the peripheral processes involved in the electrodermal response. This model, described in the interim report, ascribes conductance changes having a slow recovery rate and negative potential waves, also of slow recovery rate, to the rise of sweat in the ducts. The fast recovering conductance waves and the positive potential waves are attributed to behavior of a neurally controlled membrane readily accessible to surface solution, and involved in the rapid reabsorption of water from the skin surface. An analysis of the manner in which these components combine was used to explain the complex wave forms obtained under actual recording conditions.

From this model it was concluded that the half-time of the recovery process of the skin conductance response should be a meaningful index of the amount of fast-recovering (membrane) component in the response. A series of behavioral experiments was analyzed with the use of this index to determine whether it distinguished different behavioral states, for example, alerting for a task as opposed to execution of the task, and relaxing as opposed to task performance. The measure successfully distinguished between these conditions even in cases where conventional amplitude comparison failed to do so.

II. PROPOSED INVESTIGATIONS

A. Continuation of Physiological Investigation

Although considerable progress has been made in clarifying the nature of peripheral mechanisms, several important questions remain to be resolved. These will receive continued investigation in terms of experiments described in the current contract. Among these are:

1. Does the nail bed in fact represent a sweat-gland free area and, if so, may vascular processes explain the nail potential responses of central origin and the local positive potential responses obtained by mechanical displacement? This will be investigated by simultaneous recordings of skin potentials and reflectance plethysmographic changes from the nail plate. Efforts will also be made to alter the potential responses with electrolytes applied to the nail plate, to test for a surface membrane effect.

2. Do local potential responses (produced mechanically) depend upon a surface membrane alone, or may a vascular component be involved? The effect of surface agents and exsanguination experiments point to a surface membrane as the responsible element but surface reflectance monitoring undertaken since the last interim report demonstrates a marked similarity between the form of the local potential response and that of the change of surface optical opacity following the mechanical stimulus even in the exsanguinated extremity. The attack on this problem will consist of attempts to selectively extinguish either the local potential response (e.g., with surface anaesthetics) or the vasomotor accompaniment, e.g., by using electrical or vibratory stimuli to produce the local response.

3. Is the activity of the sweat gland observable at the surface only as a secondary effect of the rise of sweat in the ducts, or are there electrical changes at the secretory membrane which contribute to the surface potential response? [] and his co-workers have shown that intra-ductal electrodes in the cat sweat gland do not indicate responses when they are inserted deeper than the level of the germinating layer. Recent experiments under the present contract indicate that the human sweat gland behaves differently in that responses may be recorded at deeper levels. It remains to be decided whether these are due to pickup from nearby structures or in fact originate in the sweat gland.

4. In addition to the three critical questions stated above, numerous lines of approach to the clarification of mechanisms, described in the original proposal, remain to be undertaken. Special attention will be given to the combination of high frequency impedance measurement with potential and D.C. resistance measurement, and to the effects of pre-exposure to various current densities upon the positive and negative waves and upon sweat gland and epidermal responses.

B. Development of the Recovery Half-Time Index

Because of the high success with which the $t/2$ recovery index distinguishes qualitatively different behavioral states, a key effort in the continuing program will be directed toward rendering this measure maximally effective. This investigation shall be concerned with:

1. The development of a method for automatic on-line presentation of the recovery limb index.

2. The determination as to whether some fraction of the recovery time other than 50%, e.g., one third recovery to base line, is a more sensitive measure. Various fractions of the recovery time are readily selected by the automatic circuitry now planned for this operation.

3. The determination of the extent of the amplitude range in which this measure maintains its independence of amplitude.

4. The relationship of changes in the recovery index to various peripheral physiological processes as determined by independent measures such as vapor production, A.C. vs D.C. impedance, etc.

5. The classes of stimuli which tend to produce shortening or lengthening of the recovery index.

6. The lability of this measure during short term alteration of stimulus conditions.

C. Application of Electrodermal Measures as Indices of Bio-Psychological Adaptability

The interpretation of electrodermal activity as a biologically useful adaptation implies that its occurrence in response to an arousing situation may indicate effective behavior. There are, however, two additional requirements which must be evidenced by the behavior sample before this conclusion can be reached, namely that the type of adaptation be appropriate to the demands of the situation both qualitatively and quantitatively. The first implies, for example, that a defensive response to a situation which appropriately calls for maximum information intake is ineffective behavior. The second implies that autonomic activation should be graded in proportion to the situational demand, and most important, that the activation should rapidly diminish as soon as the demands of the situation are reduced. In other words the effective individual, in the interests of biological economy, would not remain continuously activated, but should be able to shift rapidly to the resting state while maintaining a system of sentries for defense purposes. He should then be capable, upon being alerted by his sentries (i.e., his receptive screen) to shift gears rapidly to the activated state. The dissection of the electrodermal response into qualitatively different adaptive reflexes should allow evaluation of the qualitative appropriateness of the elicited activation. The recovery index should allow observation of shifts in arousal even when the amplitude of the background activity fails to differentiate functional states.

The appraisal of an individual's adaptability to environmental demands will be determined by exposing him to a sequence of rest conditions alternated at unannounced times with tasks or stresses of varying demands (qualitatively and quantitatively). An index of adaptability will be constructed from the rapidity of activation and (especially) relaxation and the degree to which it is qualitatively appropriate to the task in terms of three categories of behavior, defense, aggressive task orientation, or information intake. This adaptability index will be validated against personal histories (job or military), clinical judgement of behavior, and performance on a battery of tasks aimed at assessing this ability.

ATTACHMENT B
to

was selected
for this follow-on action because of the excellent per-
formance of the principal investigator, Dr.
during the initial contract period.